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AN ANALOG INSTRUMENT TO INCREASE THE EFFICIENCY OF IDENTIFICATI--ETC(U)  
JAN 78 Y A MEDVEDEV, V A KON'KOV, A V NIKITIN

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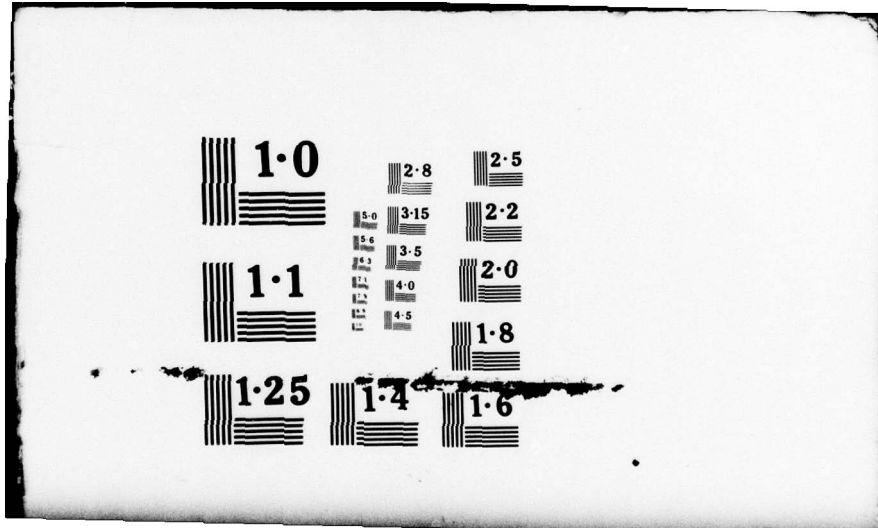
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FOREIGN TECHNOLOGY DIVISION



AN ANALOG INSTRUMENT TO INCREASE THE EFFICIENCY  
OF IDENTIFICATION OF SYSTEMS IN THE INFRA LOW-  
FREQUENCY RANGE

by

Yu. A. Medvedev, V. A. Kon'kov, A. V. Nikitin



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By: Yu. A. Medvedev, V. A. Kon'kov, A. V. Nikitin

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# U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	<b><i>А а</i></b>	A, a	Р р	<b><i>Р р</i></b>	R, r
Б б	<b><i>Б б</i></b>	B, b	С с	<b><i>С с</i></b>	S, s
В в	<b><i>В в</i></b>	V, v	Т т	<b><i>Т т</i></b>	T, t
Г г	<b><i>Г г</i></b>	G, g	У у	<b><i>У у</i></b>	U, u
Д д	<b><i>Д д</i></b>	D, d	Ф ф	<b><i>Ф ф</i></b>	F, f
Е е	<b><i>Е е</i></b>	Ye, ye; E, e*	Х х	<b><i>Х х</i></b>	Kh, kh
Ж ж	<b><i>Ж ж</i></b>	Zh, zh	Ц ц	<b><i>Ц ц</i></b>	Ts, ts
З з	<b><i>З з</i></b>	Z, z	Ч ч	<b><i>Ч ч</i></b>	Ch, ch
И и	<b><i>И и</i></b>	I, i	Ш ш	<b><i>Ш ш</i></b>	Sh, sh
Й й	<b><i>Й й</i></b>	Y, y	Щ щ	<b><i>Щ щ</i></b>	Shch, shch
К к	<b><i>К к</i></b>	K, k	Ъ ъ	<b><i>Ъ ъ</i></b>	"
Л л	<b><i>Л л</i></b>	L, l	Ы ы	<b><i>Ы ы</i></b>	Y, y
М м	<b><i>М м</i></b>	M, m	Ь ь	<b><i>Ь ь</i></b>	'
Н н	<b><i>Н н</i></b>	N, n	Э э	<b><i>Э э</i></b>	E, e
О о	<b><i>О о</i></b>	O, o	Ю ю	<b><i>Ю ю</i></b>	Yu, yu
П п	<b><i>П п</i></b>	P, p	Я я	<b><i>Я я</i></b>	Ya, ya

\*ye initially, after vowels, and after ъ, ь; e elsewhere.  
When written as ё in Russian, transliterate as yě or ě.

## RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh <sup>-1</sup>
cos	cos	ch	cosh	arc ch	cosh <sup>-1</sup>
tg	tan	th	tanh	arc th	tanh <sup>-1</sup>
ctg	cot	cth	coth	arc cth	coth <sup>-1</sup>
sec	sec	sch	sech	arc sch	sech <sup>-1</sup>
cosec	csc	csch	csch	arc csch	csch <sup>-1</sup>

Russian	English
rot	curl
lg	log



AN ANALOG INSTRUMENT TO INCREASE  
THE EFFICIENCY OF IDENTIFICATION  
OF SYSTEMS IN THE INFRA LOW-FREQUENCY  
RANGE

Yu. A. Medvedev, V.A. Kon'kov, A.V. Nikitin

A schematic diagram, principle of operation and basic characteristics of the instrument for determining the logarithmic frequency characteristics of automatic systems are given. There is one figure.

The modern methods of the theory of automatic control (frequency, graphic, electronic modeling, and others) make it possible to investigate the dynamics of practically any nonlinear system. However, the calculation means is usually the source of great errors. The experimental studies are distinguished by the combined use of different methods, and the results are practical only when reliable data are present. The absence of an industrial type of instrument for the experimental determination of frequency characteristics of automatic systems creates known difficulties. The procedure for finding the dynamic characteristics becomes especially laborious when it is necessary to obtain logarithmic characteristics.

In connection with this, the authors of this work designed and made a special instrument which allows determining the logarithmic amplitude and phase frequency characteristics in the infra low-frequency range of complex linear and nonlinear links and systems in the presence of considerable noise. As the basis of determining the dynamic characteristics by means of the given instrument, it is proposed to use the compensation method of measurement.

To construct a measuring apparatus with the use of the compensation method, it is necessary to have available the following basic assemblies: a generator, which generates simultaneously two voltages shifted by  $90^\circ$  changing according to the harmonic law; a calibrated phase shifter; low-frequency filters; and an electronic commutator.

A block diagram of the instrument and the switching of the investigated system are given in the figure. An input harmonic action is fed from the special generator to the measuring and compensation channels. The channel of the compensator consists of a calibrated phase inverter, attenuator and low-frequency filter, which is used for the separation of the main harmonic component of the signal when investigating characteristics of nonlinear elements. Limitation of the transmission band of frequencies with a visual comparison of the signals on the screen of an electron oscillograph is necessary also when there are noises in the system. The filters of both channels are identical. The measuring channel includes the regulator of amplitude, the system being investigated and the filter.

The generator of harmonic oscillations is built around three operational DC amplifiers (UPT) and is an "electronic pendulum." Stabilization of the amplitude is carried out by means of a diode circuit, which limits the signal at the output of UPT1 at a level of  $\pm 100$  V. The selection of the frequency range of the signal being generated is produced by the switching of condensers in feedback circuits UPT2 and UPT3. The frequency tuning within one range is accomplished by a change in the resistance of the resistors and transmission coefficient of the input voltage dividers. Amplifiers UPT1 and UPT4 are used as inverters (one in the circuit of the main feedback and the other, in the circuit of the limiter). The generator allows taking four voltages:  $\pm 100 \sin \omega t$ ,  $\pm 100 \cos \omega t$  with a constant amplitude of 100 V. These signals are used in the tetraquadrant calibrated phase inverter of the compensator. The voltage  $100 \sin \omega t$ , furthermore, is fed through the calibrated attenuator to the input of the device or system being investigated. The attenuator contains rough and smooth control of

the attenuation, which is accomplished by a change in the resistances of the resistors in the feedback circuit of the amplifier UPT5.

The calibrated phase inverter of the infra low-frequency range is a potentiometer to one end of which is fed the voltage  $U_1 = 100 \sin \omega t$  and to the other end,  $U_2 = 100 \cos \omega t$ . The phase of the voltage at the output of the phase inverter is proportional to the angle of turn and is taken from the slide of the divider with respect to "ground." The circuit allows creating a compensator with a separate control of the amplitude and phase, the phase shift not depending on the frequency. The switch of the quadrants is used for the expansion of limits of control of the phase, and it switches the output voltages of the generator  $\pm 100 \sin \omega t$  and  $\pm 100 \cos \omega t$  in an arbitrary combination. By means of the switch of the quadrants it is possible to obtain the compensating voltages in any of the four quadrants. Filters in both channels are built around the UPT and have the following transfer function:  $W(p) = 1 / (Tp + 1)$ . The time constant  $T$  can be changed depending on the desirable transmission band of the filters.

To operate with a single beam electron oscillograph of the S1-19 type, a commutator at two inputs is provided in the instrument. Eight resolving amplifiers of the instrument are made on the tubes of the bantam series and design-wise are located on the printed circuit board. For the convenience of operation with the instrument and the facilitation of its adjustment, all the precision dividers are made discrete. The frequency range of the generator lies within 0.01-100 rad/s. Values of indices of the scale of the frequency regulator of the generator correspond to the value  $\lg \omega$ , where  $\omega = 2\pi f$  is the circular frequency. Such a calibration simplifies the plotting of logarithmic frequency characteristics of automatic systems. The resistances of the attenuator for control of the amplitude of the output voltage of the generator are calculated in order that the readout of the amplitude attenuation could be carried out in decibels.

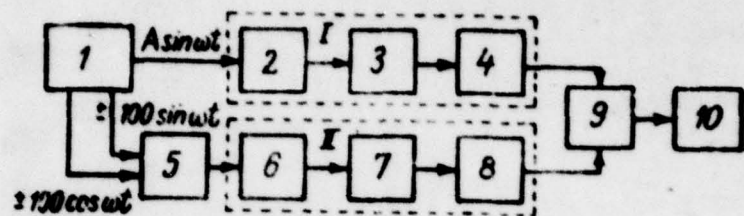
The power of the instrument is accomplished from a standard controlled rectifier ESV-3.



The method of determining the amplitude and phase logarithmic frequency characteristics consists in the following. After connecting the inputs and outputs of the device to be investigated to the instrument and after connecting the commutator to the oscillograph, set the necessary frequency of the generator and regulate the image on the screen of the oscillograph. Then by means of the phase and amplitude switches of the output voltage of the compensator, achieve complete coincidence of the signals from the measuring and compensation channels. Here the obtained values of the amplitude in dB and phase in degrees are counted on the dials of the compensator.

When high-frequency noise is present at the output of the system being investigated, it is necessary to include filters. The time constant should be selected in order to provide the maximal definition of the processes on the screen of the oscillograph. The error in results of measurements in the investigation of the linear systems is determined by the accuracy of elements of the instrument and oscillographic method of comparison and does not exceed 2-3%. Determination of the equivalent characteristics of the nonlinear systems is carried out also by using filters for separation of the first harmonic of the output signal. The accuracy of comparison of the processes on the screen of the oscillograph in this case depends on the form of nonlinearity, the correctness of the selection of the time constant of the filter and the experience of the experimenter. As a rule, it is easy to obtain results with an error of not more than  $\pm 5\%$ .

The developed instrument makes it possible to reduce considerably the laboriousness of determining logarithmic frequency characteristics of tracking systems.



Block diagram of the instrument: I - measuring channel; II - compensation channel; 1 - generator; 2 - amplitude regulator; 3 - system to be investigated; 4, 8 - filters; 5 - switch of quadrants; 6 - phase inverter; 7 - amplitude regulator; 9 - commutator; 10 - electronic indicator.

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